Road Travel Time Estimation with GPS Floating Car Data

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Abstract

Travel time data collection and estimation is an important technology method to achieve the Intelligent Transportation Systems (IST) information services. It can reflect the state of roadway traffic more accurately, be used to predict the duration of traffic congestion, and filter out the traffic abnormal states. Also, it eases the traffic congestion in time to shorten the travel time and ensure the traffic flow staying in a safe range. Estimation of travel time on urban roadways based on GPS Floating cars provides reliable traffic state data, and guarantees the veracity of information services in time. I studied on the following aspects:

- Pretreatment of the floating cars data
- Regime dividing: several periods based on the characteristics of urban traffics
- BP neural network model to predict travel time
- Application on the real data

Introduction

With the growing traffic demands, traffic systems are increasingly complicated recently. One of the important functions of ITS is to provide accurate information to the public, such as road congestion / non-obstruction, estimated travel time for pilots. Road travel time is one of the key indicators of the efficiency of ITS service (Figure 1). For traffic participants, getting relatively precise estimated travel time is a reasonable method to make travel plans. According to the information, they will avoid congested roads. Floating car technology realizes dynamic access to real traffic parameter data. This technology sets no requirement for the vehicles, and achieves all-day-long data collection, directly obtains location, speed and other information of the vehicle.

Pretreatment for the dataset

In the process of floating car data collection, there are interferences to the equipments resulting decreased accuracy and reliability of the data acquisition. There are two types of the failed data: fallacious data and missed data.

The steps of pre-treatment:

- Set thresholds according to the real situation, such as speed limit of the roads while keep the random fluctuations
- Repair the data with linear interpolation method

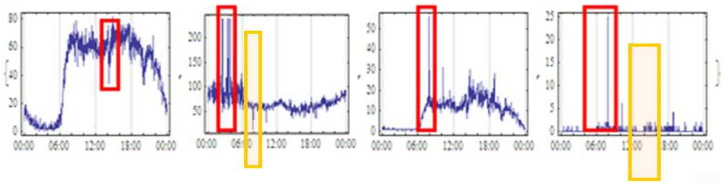


Figure 2 The original distribution of travel time series (including the abnormal and missed data)

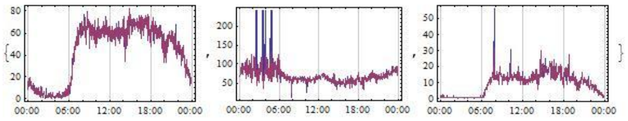
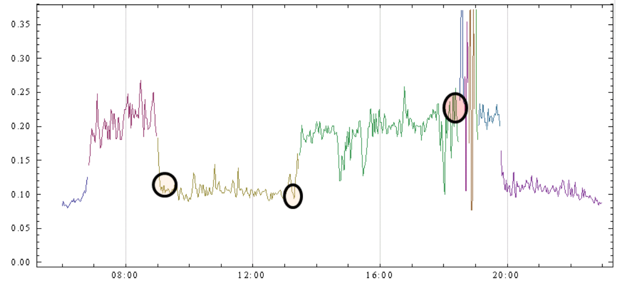


Figure 3 The data after repaired

Road Travel Time Estimation

The Change Point of Traffic State

- According to urban traffic characteristics, the floating car data can be divided into different stages along the time axis.
- The corresponding feature obtained from data is the traffic state changes, such as rush hours, normal hours, and night hours. This state is usually obvious.
- However, on different roads, the change times of status (the change point of the time series) are different. Therefore, it has a significant effort for the accuracy of estimation to explore various "change points" of the traffic states.



- Determine the change point based on the peaks and troughs of the curve, and the variables, such as standard deviation, average mean, etc.

BP Neural Network

- Processing units (neurons, shown with a circle in the following figure). The processing unit of input layer transfers input value to adjacent connection weights. The processing units of hidden layer and output layer sum their input values and calculate output values according to the transfer function.
- Connection weights (such as V, W). The weights connect processing units, and their values depend on the correlation between processing units.
- Layer. Generally, there are input layer x, the hidden layer y and output layer o in neural network system.
- Threshold. Its value can be constant or variable, which enables the network to obtain the desired function agilely.
- Transfer function F. It is the processing unit who transfer input data as output ones, and usually a nonlinear function.

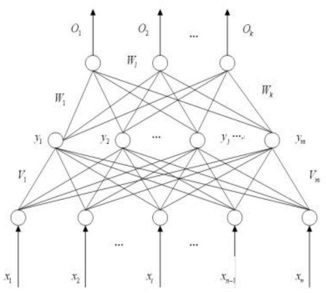


Figure 4 The Structure of BP Neural Network

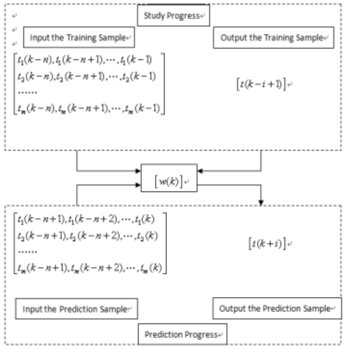


Figure 4 The Input and Output of BP

Data and Analysis

- The data is obtained from 16 floating cars travelling on 4 highways, 8 local ways in the urban area of Beijing

Table 5 The results of the change points selection

Range	Parameter e_0	Select results	Maintained results
(1~200)	***0.2***	***92***	***92***
(100~300)	***0.2***	***151, 221, 224***	***151. 221***
(200~400)	0.2	None	None
(200~400)	***0.1***	***222, 377***	***377***
(300~510)	0.2	396	None
(300~510)	***0.1***	***381, 396, 414***	***414***

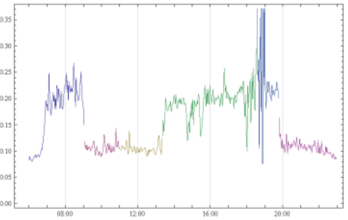


Figure 5 The result {1, 92, 151, 221, 377, 414}

- As the result shown in Figure 5, the travel periods are divided in 6:00～9:00, 9:00～11:00, 11:00～13:22, 13:22～18:34, 18:34～19:48, and 19:48～23:00 regimes.
- Apply BP neural network model to predict the travel time

Time	Real value(min)	Predicted (min)	Time	Real value(min)	Predicted (min)
7:35:00	1.596	1.639	9:15:00	1.451	1.499
7:40:00	1.861	1.738	9:20:00	1.451	1.326
7:50:00	2.445	2.125	9:25:00	1.295	1.377
7:55:00	2.445	2.478	9:30:00	1.344	1.413
8:00:00	2.449	2.576	9:35:00	1.352	1.401
8:05:00	2.407	2.717	9:40:00	1.406	1.515
8:10:00	2.407	2.198	9:45:00	1.409	1.422
8:15:00	2.400	2.340	9:50:00	1.385	1.347
8:20:00	2.421	2.275	9:55:00	1.286	1.116
8:25:00	2.421	2.374	10:00:00	1.087	1.211
8:35:00	2.180	2.200	10:05:00	0.996	1.297
8:40:00	2.070	2.434	10:10:00	1.003	1.245
8:45:00	1.690	2.017	10:15:00	1.177	1.029
8:50:00	1.568	1.823	10:20:00	1.177	1.156
8:55:00	1.397	1.602	10:25:00	1.249	1.112
9:00:00	1.337	1.523	10:30:00	1.245	1.054
9:05:00	1.337	1.109	10:35:00	1.261	1.443
9:10:00	1.451	1.372	10:40:00	1.054	1.378

Table 6 The comparing between the predicted travel time values and the real values

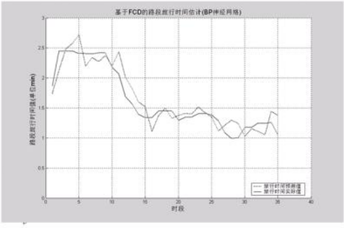


Figure 6 The predicted travel time (BP neural network)

Conclusion

Intelligent transportation system (ITS) is one of the best ways to solve urban traffic congestion, to improve traffic safety, and to promote the efficiency of the road utilization. It is a real-time, accurately and efficiently integrated transport management system established on the basis of multiple advanced information technologies. This research employs the change-point analysis and BP neural network model to forecast the short-term travel time. We can reach the conclusion that:

- The prediction results based on floating car data are better than the ones based on other data. There are diverse factors affecting the travel time, such as traffic accidents, congestion. Floating car technology has no requirement for pilots and vehicles, provides reliable data, and achieves a more accurate forecasting.
- Travel time prediction based on change point estimation increases the accuracy of the prediction for travel time.

Future Work

- The model in this research is suitable for short-term prediction. It may not be suitable for long-term forecasting.